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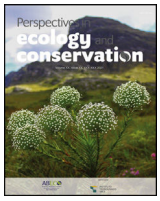

Essays and Perspectives

Legislation and pollination: Recommendations for policymakers and scientists

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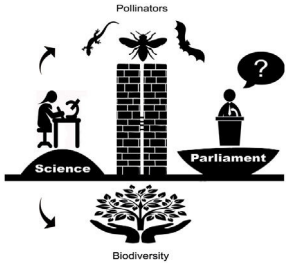
HIGHLIGHTS

- Public awareness policies needs to be more comprehensive and interdisciplinary.
- Brazilian scientists should be consulted and participate in proposing laws.
- Non bee pollinators must be considered in protective policies.
- Brazilian largest biome has the lower number of pollinator-policies.
- Policies on biodiversity protection in cities and on long-term monitoring are necessary.

GRAPHICAL ABSTRACT



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ABSTRACT

Global biodiversity declines and concomitant increases in diseases and calamities indicate the need for well-founded measures to provide sustainable development, guaranteeing material progress and social welfare, while safeguarding biodiversity. Public policies are important in this context as they provide norms for actions to deal with economic and socio-ecological problems. Nevertheless, scientists and legislators have conflicting opinions; perhaps due to lack of knowledge on both sides. Scientists provide information that is never used by legislators and legislators provide laws that do not provide biodiversity protection. Review and understanding of local legislation are thus crucial to understand those relationships and to provide robust suggestions for change. Here, we review Brazilian legislation concerning pollinator-relevant policies to show how these subnational policies fit calls from the science community. We also compared Brazilian legislation related to pollinator and biome protection to legislation in other countries. We found 314 national, state, and municipal laws on apiculture, meliponiculture, economic incentives, pesticides, pollinator awareness, and city planning. Although scientists are producing high-quality science to provide information for legislative standards, that information is not being used. Brazilian policies are numerous, but, in general, lack the standards to provide sustainable conservation. The main flaws are related to the lack of knowledge about non-bee pollinators, integrated pest management and GM crop risks, and lack of long-term monitoring of pollinators and pollination. More comprehensive and interdisciplinary legislation is needed to accomplish crop and biodiversity protection. Brazilian scientists should be consulted more often and participate in proposals for laws relating to pollinator conservation.

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Introduction

Sustainable development aims to guarantee material progress and social welfare while safeguarding the resources and natural heritage of peoples, and thus safeguard the environment and its natural resources (Hák et al., 2016). We urgently need to reconsider our priorities and articulate the interconnections between biodiversity and ecosystem services for sustainable development (Reyers and Selig, 2020). This is demonstrated in recent epidemics and calamities, reflecting lack of planning by governments (Brancalion et al., 2020; Hakovirta and Denuwara, 2020). We need to reduce habitat and biodiversity loss, concomitant with economic and social development (Muñoz-Pascual et al., 2019). Pollinator decline is caused by loss of forage and nesting habitats associated with other stressors, such as pesticides and pathogens (Potts et al., 2010), and this has consequences for food security and wildlife, as well as economic stability for nation-states.

Globally, calls for pollinator-policy targets reinforce the importance of pollinator studies for conservation (Dicks et al., 2016; IPBES, 2016). Dicks et al. (2016) listed ten policies for pollinators that include synergy with international policy objectives. However, those policies are not being incorporated in national and subnational legislation. Hall and Steiner (2019) examined US policies related to pollinators and found that, with few exceptions, policies constitute only nascent steps in addressing the pollinator-health crisis. A major problem is related to conflicting opinions of scientists and legislators, which may reflect the general lack of understanding of the importance of local legislation.

One of the main arguments for the importance of pollinators is related to their economic value and cost-benefit analysis is used to inform policymakers (Porto et al., 2020). In Brazil, pollinators contribute at least US$12 billion to total annual agricultural economics (Giannini et al., 2015b), but this value is likely to be an underestimate as our economic valuations still fail to represent the complex sets of benefits of pollinators and the importance of their ecological functions (Porto et al., 2020). Research on pollination/pollinators has been undertaken mainly in developed countries, and almost all the reviewed policy papers on the economic value of crop-pollination services have been published in economically advanced countries (Porto et al., 2020).

A recent review of pollination assessment in Brazil (Wolowski et al., 2019) included pollinator threats, policies, and opportunities, but this review was mainly based on academic publications located through the Web of Science TM, Scopus®, SciELO, PubMed and Scholar), and did not consider Brazilian legislation. The lack of information on Brazilian laws is also evident in another recent review made by Porto et al. (2020), where the authors evaluated the economic valuation of crop services across the ecological and economics literature and reviewed estimates of monetary values of crop pollination services, as well as the investments (research funding/grants) and policy actions associated with pollinators and pollination. Both reviews are valuable to help understand how scientists provide information for policy innovations.

Brazilian legislation is hierarchical and the Federal Constitution guides all other national laws. States and municipalities can legislate on the environment, but this must supplement and not contradict the constitution. State and municipal laws are necessary to adapt the legal system to the local reality since it is impossible for the Constitution alone to cover all the peculiarities associated with social, territorial, cultural, and economic pluralities. This means that there are general rules from the Union, regional rules from the states, and local rules from the municipalities. Analysis of different legislative scales (national, subnational) may help us to understand the values, opinions and desires of the populations represented, and promote interaction between scientific information and legislation (Donovan et al., 2015).

In this study, we analyze pollinator-relevant Brazilian legislation and discuss how these subnational policy innovations fit calls from the science community. We also evaluated Brazilian legislation concerning pollinator and biome protection vs the international scenario and how the policy targets proposed by Dicks et al. (2016) are embraced by Brazilian legislation at different levels (national, subnational). This study does not include proposed bills and only examines bills that have been passed by legislatures and approved by state governors as law.

Analysis

In early 2020, we searched for policy passed by Brazilian state and territory legislative bodies using boolean searches in Portuguese for pollinator and policy, state policy and pollina*, pollination, neonicotinoids, pesticides, colony disorder, beekeeping, honeybee, and honey bee. We emphasized bees in our search given the recognition of their role in pollination, but we did not exclude the other pollinator groups in our search. Other methodology details are included as Supplementary material (Sup1) in which we outline how we gathered and analyzed policies via content analysis, then we provide a thematic analysis of these laws.

Adapting and expanding the categories of Hall and Steiner (2019) to Brazil's reality we undertook a qualitative content analysis (Hall and Steiner, 2020) including the following categories: (1) apiculture practices, (2) awareness (laws with the main purpose of increasing awareness related to pollinators), (3) city planning (prohibition of beekeeping in cities), (4) economic aspects (such as taxes or financial incentives for bees), (5) meliponiculture practices (when law includes or is exclusive to meliponine bees – i.e. stingless bees belonging to Hymenoptera, Apidae, Meliponini), (6) pesticide use (Sup 1).

Brazilian constitution vs state and municipal laws

Since the Constitution is the most inclusive legal sphere, which sets the basic rules, it determines the joint responsibility of the Union, the States, the Federal District, and the Municipalities to protect and preserve the environment (Brasil, 1988). This occurs in three legislative spheres: National (referring to the whole nation), State (thus linking only the municipalities belonging to the unit of which the state legislation is part), and municipal (with coverage only in the municipality), so that national laws are valid for the whole country, state laws for states and municipal laws for municipalities. Often there is no direct legislation related to pollinators, but one of the main causes of pollinators decline (pesticides) (Goulson et al., 2015) is a recurring theme.

The constitution determines the need to protect fauna (article 225, VII – Brazil, 1988), but faunal legislation relates only to vertebrates. Protection of pollinators and invertebrates in geberal, is included only implicitly since there is nothing specific concerning these groups. Thus, although pollinators are essential components of agriculture and the environment, from a legal point of view, this topic is only treated incipiently and usually indirectly.

In contrast, pesticide legislation can be found in both national laws and the Constitution (Sup 5). The Union is responsible for analyzing, approving, and registering pesticides (through federal agencies linked to health, the environment, and agriculture), in addition to controlling and inspecting produce, and production, importation, and export of pesticides (through the Ministry of Agriculture, Livestock and Supply – MAPA). Pesticide laws are related to methods to increase yields, environmental protection through the protection of agriculture or the prevention of damage to human health, and the prevention of disease transmission. Pesticide use and regulation in Brazil is highly polemical due to the large num-

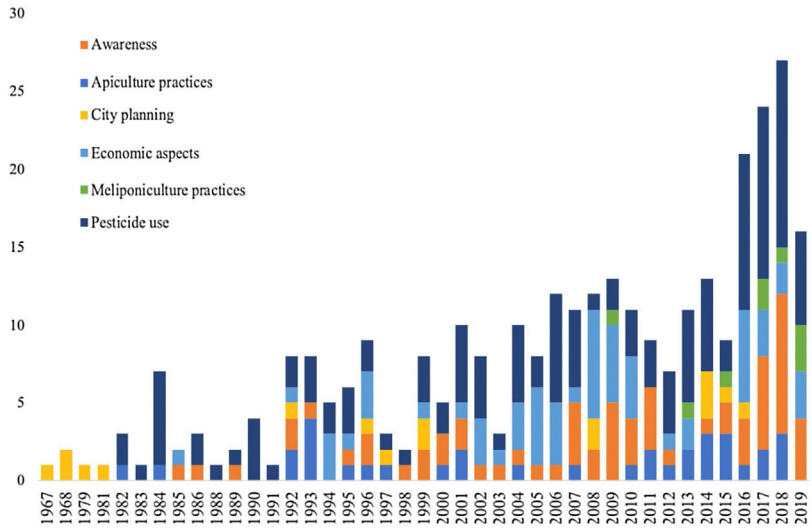

Fig. 1. The number and main categories of pollinator policies approved by Legislatures in Brazil by year.

Table 1
Categories of pollinator-relevant legislation of Brazil.

Main category	Number
Apiculture practices	35
Awareness	62
City planning	17
Economic aspects	59
Meliponiculture practices	9
Pesticide use	132

ber of products permitted (some prohibited in other countries), many approved since 2019 (Coelho et al., 2019). This indiscriminate release of products, instead of boosting yields, can harm human health, biodiversity, and the Brazilian economy (Coelho et al., 2019). Concomitantly, there has been a reduction in research investments and popular participation in several environmental committees, as well as weakening of monitoring (Thomaz et al., 2020).

Pollinator legislation in states and municipalities

We reviewed pollinator legislation from 1967 to 2019. The laws before 1987 were subject to the 1967 constitution (Brasil, 1967) that did not contemplate environmental protection, although one federal law (Law 5197/1967) had general comments related to fauna, which was considered State property, and thus its use, pursuit, destruction, or hunting was restricted or prohibited. Nevertheless, we included the few legislative acts related to pollinators published before 1987.

Of the 314 state and municipal legal documents, most (266, 84.7%) were from states. Most of the documents were related to pesticide use (133), followed by awareness (62) and economic aspects (59) (Table 1). Meliponiculture laws only began to appear in 2009, but bee-keeping practices were legislated since 1982. Keywords related to pesticide use, economic aspects, and awareness appear almost together over time (Fig. 1).

The region with more laws was the northeast (113), and Pernambuco State within this region had the highest number (38), most of which were related to pesticide use (15). The state with the highest number of laws related to awareness of pollinators was Rio de Janeiro (13) and only seven states have laws that are specific to Meliponiculture practices (Fig. 2).

At the National level, we found 20 federal laws related to pesticides or bees. Laws referring to pesticides included mainly regulative and/or administrative roles of agencies and products. Laws related to bees focused on bee products (honey, mead), administrative roles, or awareness (Sup 2). Below we present the six categories proposed in more detail.

Apiculture practices

We found 35 state and municipal laws related to apiculture practices. These laws were mainly related to bee-product inspection (sales, content analysis, establishments). We found one law with measures to encourage the development of beekeeping (State Law – 14009/2001 in Minas Gerais) in which bees and the native honey flora are considered objects of protection, conservation, and preservation in the State. This law is complex and integrative, attributing to the Executive Branch responsibility for preventative actions against the destruction of bees, honey or pollinators, native or not, the identification of areas with the greatest beekeeping potential in the State, regulation of beekeeping activity through the creation of instruments of quality control and origin of the products and the elaboration of a beekeeper register. It also requires the development of research aimed at improving beekeeping, production technologies, and product quality. This law contemplates the different actors involved in beekeeping, such as class representatives and cooperatives or beekeeper associations, public or private institutions giving technical assistance and rural extension, education, and research through participation in the planning and execution of the actions referred to in this article.

Awareness

Some laws were propagated to increase public awareness, with the main objective to protect, conserve, valuate and foster sociobiodiversity and agricultural products. We found such laws in all Brazilian regions (North, North-east, Mid-east, South, and Southeast). These laws have become more frequent in recent years; three between 1985 and 1989, nine between 1989 and 1999, and 19 after 2000.

The content of those laws is diverse, related to the inclusion of honey or organic food in school lunches; promotion of campaigns to raise awareness among rural people and entrepreneurs about the harm caused by the intensive and indiscriminate use of pesticides and soil degradation; stimulus to organic practices or products through green seals or organic markets; celebration days, such as the “State day to combat pesticides”; recognition of native bees as well as the state’s honey flora as public domain and thus being

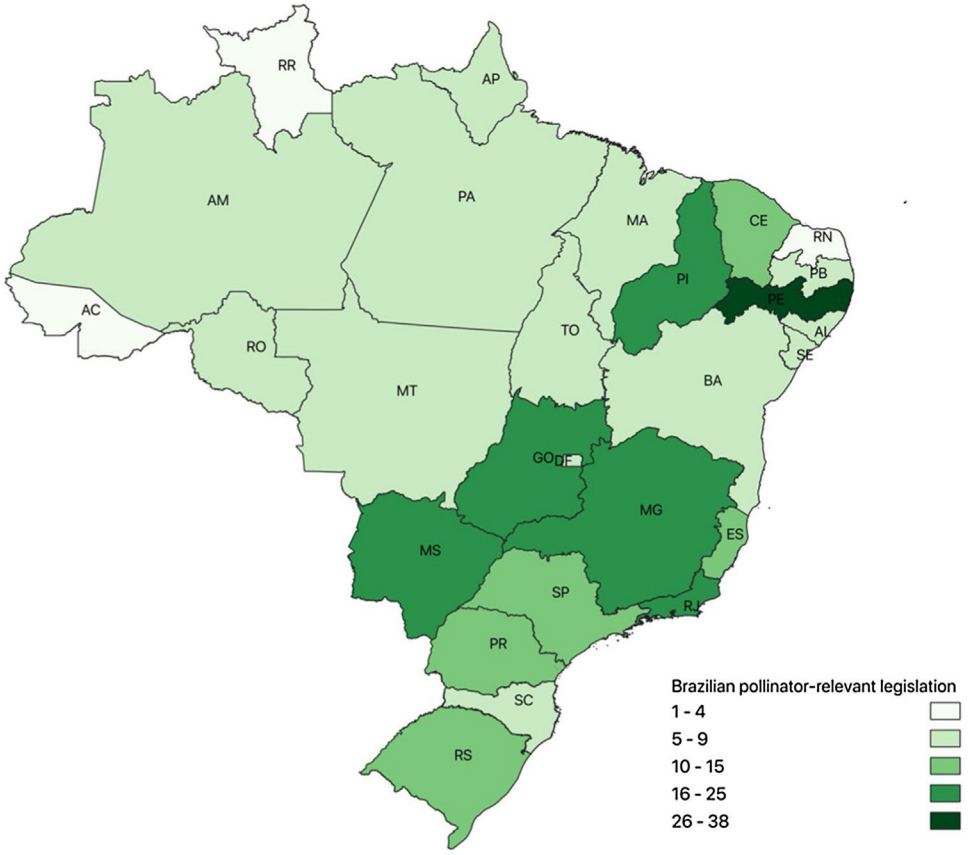

Fig. 2. Brazilian pollinator-relevant legislation by state.

the object of protection and measures to prevent their destruction; state policy on agroecology and organic production – for example, the PEAPO (State law 21.146 in Minas Gerais) in which the main goal is to promote and encourage the development of agroecology and organic production.

City planning

About half the laws (7 of 17) within the city-planning category referred to the prohibition of beekeeping in urban areas and were spread over many years (1967, 1968, 1979, 1992, 1996, 2014). The other city-planning laws were related to city administration, with secretariats and/or public-agency structure related to providing advice and assignment of bodies for regulation or inspection of pesticides.

Economic aspects

We found 59 laws related to economic aspects of pollination and/or bees, and they were promulgated in most of the country except for the southern region. Their main content was related to taxes (26) or tax incentives, to the transfer of funds or tax exemption for producers or companies, or as budget resources for educating beekeepers (29). Taxes related to pesticides or bees included different aspects, such as life insurance or a health-risk bonus for handling and transporting fertilizers, pesticides, and the like (Law 11.125/1994 in Pernambuco); fee exemption for empty pesticide packaging (Decree 10.471/2001); exemption from taxes on operations for products included in the National Program for Strengthening Family Agriculture – PRONAF, which deals with Article 19 of Federal Law No. 10,696, of 2 July 2003, aimed at meeting the demands for food and nutritional supplementation of the social programs of the State, under the terms of Agreement 234/2008 – SESAN, and the Term of Adhesion 119/2012, signed with the Federal Government. There were also laws related to tax benefits and rural credit for bee products (honey and related) and one law related to the allocation of funds for pesticide campaigns in State Law 21971/2016 in Minas Gerais), that could be interpreted as awareness.

We also found one decree (Decree 9.130/2017 in Goiás) related to payment for environmental services which promulgates cooperation and participation, understood as the joint action of society and the government authorities, with the scope of defending and preserving the environment for present and future generations. Sustainable development was addressed from the perspective of making economic-social development compatible with the preservation of the environment and ecological balance. These laws require that the polluter pays the costs of preventive or repair measures and protectors are recognized through compensation to those who work in the preservation, conservation, or recuperation of the environment, instituting and maintaining environmental services.

Meliponiculture

We found only nine laws related to meliponiculture, although the State Law- 14009/2001 in Minas Gerais can also be applied to meliponine bees, despite our including it in the apiculture category because this law includes the stingless bees in its first and second articles. Those laws related to meliponiculture are in general very recent; the first was created in 2013 (Law 16.171/2013) and most were published between 2017 and 2019. Those laws were present in the north, northeast, southeast, and southern regions, and have similar content. They consider management, transportation, research for commercialization or socio-cultural purposes,

scientific research, promotion, environmental education, conservation, exhibition, and reproduction of stingless bees.

Pesticide use

Pesticides are dangerous agricultural inputs that the state must regulate. The Brazilian law on pesticides (7.802/89), attributes the responsibility to the states and federal district to legislate on the use, production, consumption, trade, and storage of pesticides, their components as well as inspecting the use, consumption, trade, storage, and internal transport. This legislation also states that is up to the municipalities to legislate supplementally on the use and storage of pesticides, their components, and the like. This explains the large number of laws in states and municipalities regarding the use or restrictions on pesticides.

In some states (e.g. DF, Alagoas, Mato Grosso do Sul, and Ceará) and municipalities within states (e.g. Minas Gerais, Acre, and Espírito Santo), there are bans on the use of aircraft for spraying pesticides. This restriction only applies to some areas and not the whole state or municipality. Pesticide use is usually prohibited within a radius of ten kilometers of inhabited areas and conservation units, and this distance may be increased or decreased in certain areas (conditioned by a technical, sanitary, and environmental study). In the latter case, the minimum distance is one kilometer.

In almost all laws, pesticides are defined as the products and agents of physical, chemical, or biological processes intended for use in the storage and processing of agricultural products, in pastures, in the protection of native or planted forests, that have 50% lethal dose (DL50) less than 2 mg for bees. There is also an understanding that pesticides are useful to increase agricultural productivity, preserving the quality of the products when the application of pesticides is under the requirements of federal legislation, including the implementation of actions that aim to protect water sources and basins, the clean-up and the reforestation necessary for the potential flow of watercourses, in addition to their preservation from pesticide pollution, domestic sewage and or industry and other deleterious effects to ecosystems.

In some states, there is a clear awareness of the need to regulate the use and disposal of pesticides and their packaging. For example, the State of Pernambuco prohibits the importation, selling, or use of pesticides whose sale has been prohibited in their country of origin. Other states, such as Paraíba and Minas Gerais, require that pesticide registrants provide a waste-management plan contemplating the environmentally appropriate destination of packaging and the installation of collection centers, adopting solutions that enable reuse, recycling, treatment, and safe final disposal of packaging.

In some municipalities, there are other constraints, such as the prohibition of chemical weeding or buffer zones where pesticides are forbidden or their use is conditioned on the consent of federal agencies. On the other hand, there are also laws related to tax exemptions for insecticides, fungicides, insecticides, herbicides, parasiticides, germicides, acaricides, nematicides, rodenticides, defoliants, desiccants, spreaders, and adhesives.

Pesticides are used at high levels in the states of Mato Grosso, Rondônia, Paraná, Santa Catarina, and Rio Grande do Sul (Censo Agropecuário IBGE/2017). In those, most laws related to pesticides (i.e. were the primary search returned the keyword pesticide and before categorization on categories described in Table 1) were regulated use, except for Rio Grande do Sul, where there were also laws related to awareness (5 of 14 pesticide-related laws). These were related to teaching in schools about ecology and pesticides and the inclusion of organic food in the school lunch.

Dangerous use of pesticides is higher in the three regions that most consume pesticides in Brazil: Midwest, South, and Southeast (Censo Agropecuário IBGE/2017). In those regions, most laws were related to pesticide use: Midwest – pesticide use (27 of 44 laws); Southeast – awareness (24 of 53) followed by pesticide use (22 of 53); and South – pesticides (19 of 27).

It is clear from the differences among laws that the regulation of pesticides is politically controversial. This topic is relevant for reasons of public health, environment, and sustainable agricultural, especially given the high growth in agricultural production and the use of pesticides in the country since the early 1990s, but it is also highly influenced by political groups (Coelho et al., 2019), reflected by several Brazilian laws to make pesticide use less strict (e.g. Law projects 6.299/2002, 1.687/2015, 3.200/2015, 6.670/16). The unregulated use of pesticides has provoked criticism from scientists, non-governmental organizations (NGOs), and some segments of government, especially technicians from the environmental and public health areas.

Indiscriminate pesticide release aggravates the Brazilian environmental crisis as many of those products were already prohibited in other countries due to proven negative effects on human and environmental health (Coelho et al., 2019). This is accompanied by the dismantling of environmental policies and protection of conservation areas, reduction in research investments, and popular participation in several environmental committees, as well as the weakening of monitoring (Thomaz et al., 2020). Differences among regions regarding use demonstrate a lack of integration of policies to protect pollinators at different scales (from federal to municipal) that can further worsen human, economic, and environmental health.

Brazilian context on pollinators and biome protection

Concomitantly with the decline of pollinators, the fraction of pollinator-dependent crops used in agriculture has increased over the years (Aizen et al., 2019, 2008). In Brazil, most cultivated crops depend on pollinators, which contribute almost 30% of the total agricultural production value (US$ 12 billion/annually) (Giannini et al., 2015b). Due to the economic importance of agriculture, Brazilian researchers have contributed to the discussion on the importance of pollinators at national and international levels. In 1998, as a result of the meeting “Conservation and Sustainable Use of Pollinators in Agriculture, with Emphasis on Bees” , the document “The São Paulo Declaration on Pollinators” (Dias et al., 1999) was produced and signed as a commitment to the Convention on Biological Diversity (CBD), in the thematic program for Biological Diversity in Agriculture, created in 2000 and approved in 2002, the International Initiative for Conservation and the Sustainable Use of Pollinators (IPI).

Although the honey bee is considered the most important commercial pollinator among domesticated bees, accounting for approximately 90% of managed pollination (Allsopp et al., 2008), other managed bees, as well as non-bee pollinators, are equally or more effective for pollination (Garibaldi et al., 2013; Rader et al., 2016; Viana et al., 2014). Nevertheless, Brazilian legislation does not consider explicitly the non-bee pollinators.

We still have large gaps in our knowledge of the role of many species in the pollination of crops, especially on the efficiency and effectiveness of pollinator species (Hipólito et al., 2020). This lack of information is even worse for native pollinators which pollinate several Brazilian crops (Giannini et al., 2015a) and are distributed in several biomes in Brazil.

Brazil is one of the most biodiverse countries in the world and has a wide range of ecosystems. It covers more than 8 million km^2 represented by the Amazonian (49.29%), Brazilian savannah (23.92%), Atlantic Forest (13.04%), Caatinga (9.92%), Pampa (2.07%), and Pantanal (1.76%) biomes (CBD, 2008). However, this complexity is not reflected in the number of legislative acts related to pollinator policies. The Atlantic forest (178) followed by the Brazilian savan-

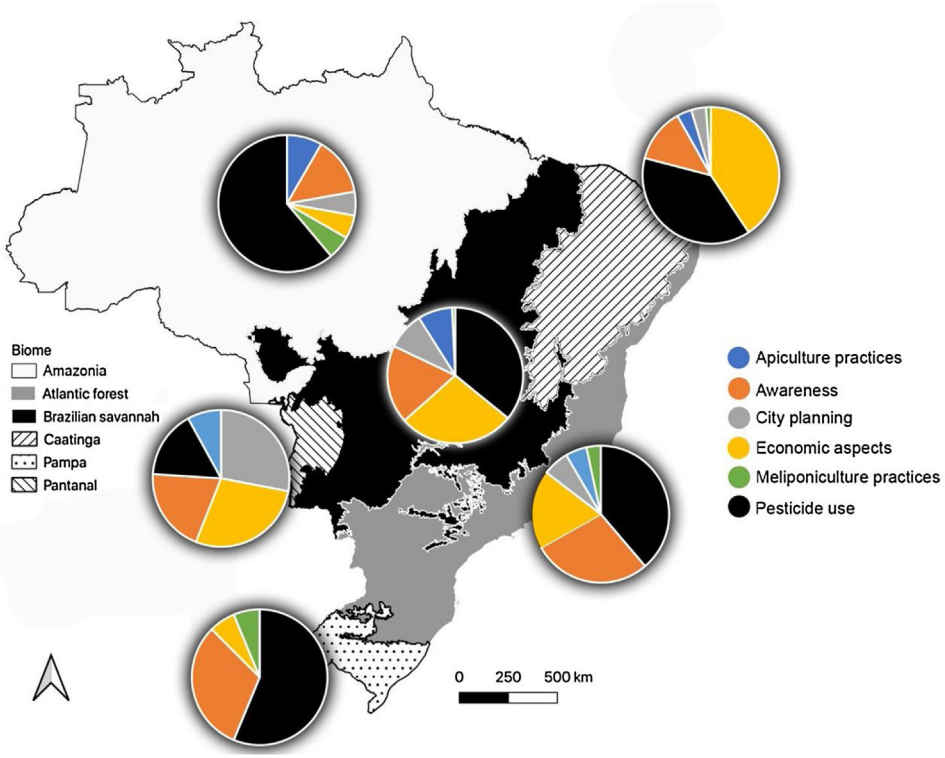

Fig. 3. Relative frequency of pollinator-relevant legislation in Brazilian biomes. Graphs demonstrate the proportion of legislative acts within the biome.

nah (134) has the highest number of laws (Sup 3). Most laws in most biomes are related to pesticide use (Fig. 3); the exceptions are the Caatinga and Pantanal, where most laws are related to city planning or economic aspects. In some biomes, there are no laws related to apiculture or meliponiculture practices (Pampa and Pantanal), but there are laws related to the awareness of bees or pesticides.

All Brazilian biomes are threatened by human activities that directly affect pollinators (Joly et al., 2019). Deforestation, intensive farming, mining, desertification, mega infrastructure projects, burning, and lack of areas destined for conservation are among the causes of the greatest impacts on pollinators (Wolowski et al., 2019). According to the Report of the United Nations Program for the Environment, released in 2016, Brazil recorded, between 1990 and 2015, a reduction of almost 55 thousand hectares in the size of its forests, with the Amazon and the Atlantic Forest being the most affected biomes in this period.

Studies in the Atlantic Forest and the Amazon indicate that greater forest fragmentation is associated with a decline in the abundance and diversity of bees and butterflies in remnants of native vegetation (Brown and Albrecht, 2001; Ferreira et al., 2015; Ramalho et al., 2009). In the Atlantic Forest, deforestation associated with the expansion of *Pinus* plantations for paper production (Freitas et al., 2009) has been identified as a cause of the decline of social bees that nest in tree hollows, such as species of the genus *Melipona* (Marques et al., 2003). Such changes may further compromise the viability of pollinator species, many of which are associated with the pollination of crops.

Transport and the management of species of bees outside their natural areas of occurrence could also lead to the loss of within-species genetic diversity (Jaffé et al., 2016). The conservation of the remnants of the Atlantic Forest and the recovery of its native vegetation is important for sustainable development, with emphasis on protected areas, such as Conservation Units (SNUC – Law nº 9.985/2000) and Indigenous Lands (Statute of the Indian – Law No. 6001/1973), in addition to Permanent Preservation Areas and Legal Reserves (Forest Code – Law No. 12,651/2012). The biome is also protected by Law 11.428/2006, known as the Atlantic Forest Law, regulated by Decree 6.660/2008. However, illegal deforestation and burning still occur in the biome.

The Brazilian savannah lost approximately 60% of its original area in a period of 30 years (Machado et al., 2004), resulting in a significant loss of floral resources and nesting sites for several species of pollinators. According to the Food and Agriculture Organization of the United Nations (FAO), by 2030, Brazil will be responsible for the largest national expansion of agricultural production, an increase driven by the deforestation of natural areas.

Ten policy targets proposed by Dicks et al. (2016) and Brazilian legislation

Dicks et al. (2016) proposed ten policies to safeguard pollinators that are general and range from pesticide regulation to the management of pollinators and landscapes (Sup 2). We analyzed the State and Municipal laws that are related to one or more of the policies proposed by Dicks et al. (2016) (Sup 4). We found that Brazilian legislation fails to address three areas advanced by Dicks et al. (2016): integrated pest management, GM crop risks, and long-term monitoring of pollinators and pollination. Of legislative acts that accomplish at least one of the suggested policies (173), the most frequently cited policy was related to pesticide regulatory standards (136) (Table 2). The second most frequent policy was related to the regulation of movement of managed pollinators (13), but only three also treated other aspects, such as recognizing pollination as an agricultural input (2) and the support of diversified farms as a means to conserve pollinators (1).

On a positive side, we found some laws included in categories other than those proposed by Dicks et al. (2016) that could be important to increase public perception of the importance of pollinators. Some legislation recognized the importance of pollinators in natural habitats (n = 5), and some laws recognized that publicity campaigns and the promotion of organic food or school lunches are needed to promote and encourage organic agriculture (n = 29).

Table 2
Pollinator-relevant legislation in Brazil based on policy targets proposed by Dicks et al. (2016).

Dicks et al.'s (2016) policy targets	Number of Brazilian policies addressing targets
One target only:	
Raise pesticide regulatory standards	136
Regulate the movement of managed pollinators	10
Develop incentives, such as insurance schemes, to help farmers benefit from ecosystem services instead of agrochemicals	2
Recognize pollination as an agricultural input in extension services	3
Support diversified farming systems	3
More than one target in the same law:	
Conserve and restore "green infrastructure" (a network of habitats that pollinators can move between) in agricultural and urban landscapes	4
Pesticide regulatory standards and support diversified farming systems	1
Regulate the movement of managed pollinators and Recognize pollination as an agricultural input in extension services	2
Incentives to help farmers benefit from ES and fund participatory on ecological intensification	3
Incentives to help farmers benefit from ES and support diversified farming systems	1
Incentives to help farmers benefit from ES; support diversified farming systems and fund participatory on ecological intensification	7
Regulate the movement of managed pollinators; recognize pollination as an agricultural input in extension services and support diversified farming systems	1

However, although these laws are important, as also observed for US legislation (Hall and Steiner, 2019), most public-awareness policies are simply informative, and lack deadlines and appropriated funding. Another point of concern is that the perception of pollinator importance (when included) is exclusively related to bees. Some laws are also quite incomprehensible in terms of how to address restoration and/or conservation aspects, probably because we lack legislation that addresses information on how to promote integrated pest management and develop long-term monitoring of pollinators and pollination, which is crucial to provide elements for verifying the effect of any conservation and/or risk-related action. It is clear that we need much more comprehensive and interdisciplinary legislation that provides policies for crop and biodiversity protection, and that makes it clear that these components are directly related.

Final remarks

Brazilian scientists are producing valuable documents, working in national and international initiatives, such as The São Paulo Declaration on Pollinators, Convention on Biological Diversity – CBD, FAO, Brazilian Initiative on Pollinators (IBP), and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (e.g. Dias et al., 1999; Díaz et al., 2015; IPBES, 2016; Wolowski et al., 2019). From an academic point of view, scientists are producing high-quality science to provide information for legislative standards. Nevertheless, although Brazil has more than double the number of pollinator-related laws as the U.S.A. (Hall and Steiner, 2019) both countries have similar flaws in legislation regarding pollinators. Our analyses make clear the need for a new specific policy at the national level to protect pollinators.

There are no specific laws for the maintenance of pollinators, though they have been minimally protected due to laws on other matters that indirectly benefit them. The inclusion of scientists at the executive level is necessary to change this reality (Azevedo-Santos et al., 2017) at the same time that environmental issues require transdisciplinary solutions through scientific research and scientific communication with civil-society actors, decision-makers, and stakeholders (Callisto et al., 2019). It is of huge concern that other pollinators (non-bees) are simply being ignored in Brazilian legislation relating to pollinators. The absence of protective measures related to other groups of pollinators, such as birds, bats, mammals, reptiles and other insects, further aggravates environmental problems since it fails to demonstrate the need for preservation. If we want to protect pollinators, we must also have laws at different levels on non-bee pollinators, and fund more scientific studies of them.

We urge the creation of specific legislation related to integrated pest management, GM crop risks, and especially on long-term monitoring of pollinators and pollination (Dicks et al., 2016). Brazilian scientists should also be consulted more and participate in proposals for laws relating to pollination. This requires better organization and integration of the legislative and academic-research sectors.

We also need to investigate more deeply some of the points found in this study, such as why the most biodiverse biomes, such as the Amazon are the most neglected. Brazilian pollination policies seem to reflect Brazilian agriculture in which pollinators are seen as products for the profitability of honey and/or for the application and regulation of pesticides.

We must restrict the release of new pesticides before we lose the pollinators we depend on. The release of new pesticides to the market should be conditioned on more effective policies to protect pollinators at different scales (from federal to municipal) and should include the requirement to have their effects fully understood and analyzed by institutions without conflicts of interest, such as universities and research institutions. For this, we must have proper funding and investments to enable such research in those institutions.

A more sustainable and biodiverse vision of protecting biomes is needed in our legislation. This perspective should also include raising awareness of multiple actors (society, farmers, legislators) for the need to increase natural or legally-protected areas to sustain yield (Imperatriz-Fonseca and Nunes-Silva, 2010). Despite its relevance and the fact that Brazil's environmental legislation requires that private properties retain a fixed proportion of native vegetation, this instrument has been systematically criticized by the agribusiness sector and its representatives in the Brazilian Congress (Metzger et al., 2019).

The other worrying point is related to the public perception of pollinators in urban areas. About half of the world population lives in urban environments (FAO, 2017), but in Brazil, the proportion is even greater, with about 84% of people living in towns and cities (IPBES, 2016). A model of separation from nature that is reflected in the countryside-city dichotomy, and with dissociation from nature by the public. From the scientific point of view, Brazilian pollinator-dependent crops in rural areas have been intensively investigated, demonstrating their importance for food security (Giannini et al., 2015b; Wolowski et al., 2019). In contrast,

natural and/or urban environments have been neglected (but see Hipólito et al. (2019)).

Vegetation coverage in cities provides important services such as temperature regulation, protection and maintenance of rivers, mitigation of the impact of rain, pollution reduction, and promotion of people's well-being through the presence of recreational areas and contact with biodiversity. Thus, maintaining city biodiversity through its forests and pollinators in cities can have positive impacts both in the economic sphere (e.g. reduced energy consumption) and in the quality of life of residents (e.g. recreational activities). Cities with more green areas are healthier cities with a better quality of life. For this to happen, however, forests in cities must be environments in a good state of conservation to guarantee their ecosystem functions. That is, it is not enough to have forests, but ecological processes, such as pollination, need to be preserved so that we can enjoy their benefits. Legal support (specific legislation on biodiversity protection in cities environment) is crucial to those actions.

Conflict ofinterest declaration

Authors declare no conflict of interest.
Juliana Hipólito on behalf of all co-authors

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.pecon.2021.01.003.

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